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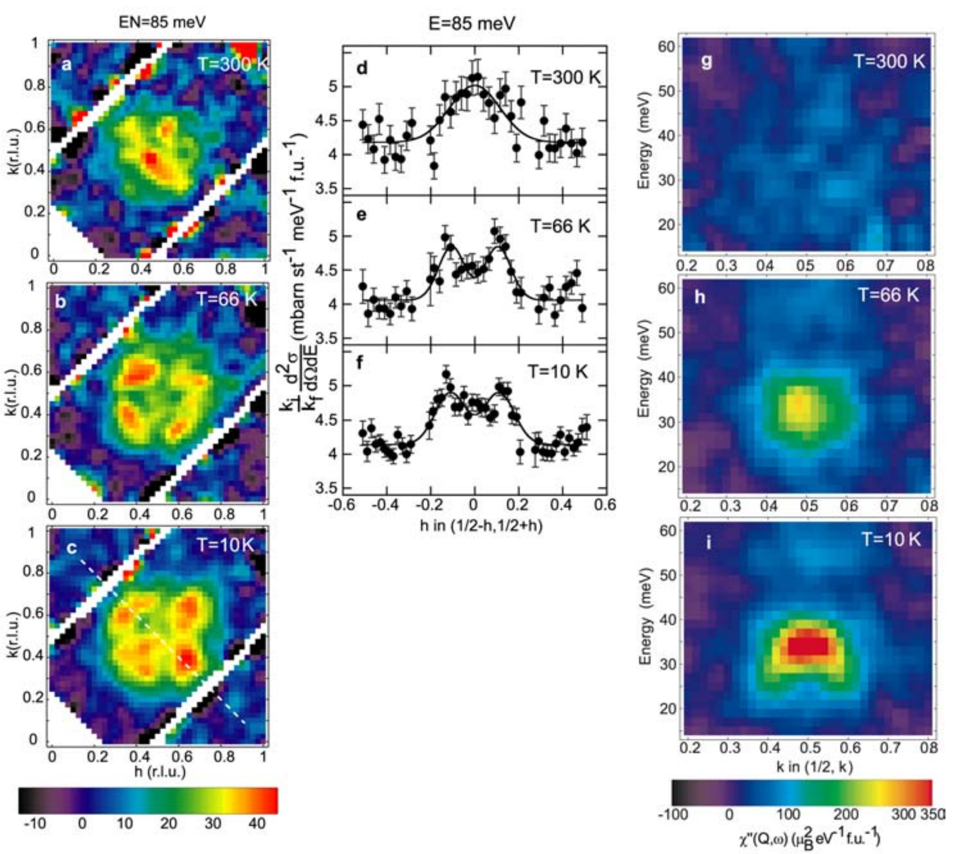
Widely held notions about why so-called high-transition temperatures superconductivity occurs may not be accurate after all, according to a team of researchers whose paper was published in the June 3 issue of ***Nature***. At the heart of the issue is the observation of new excitations that scientists at the University of Tennessee/Oak Ridge National Laboratory and elsewhere have observed using a specialized neutron scattering technique. The structure of high-energy magnetic excitations, which may provide the "glue" that enables superconducting material to operate at temperatures five times higher than is possible with other superconductors, was discovered for the first time. With this new knowledge, scientists hope to be able to design new materials with even higher transition temperatures, which will make superconductors less expensive. Superconductors have many applications, including in power transmission, medical imaging and electronics. See *Nature* **429**, 531 (2004).

Magnetic excitations in $YBa_2Cu_3O_{6.6}$



Since the first discovery of superconductivity in super cooled mercury in 1911, the complexities of the phenomenon have never ceased to intrigue the scientific community. In simplest terms, one of the defining characteristics of a "superconductor" is that it has zero electrical resistance. Electrical resistance in materials results in the dissipation of energy in the form of heat, which is where a sizable portion of transmitted power is lost. A superconducting wire for example would be able to carry current at any given voltage and over any distance (i.e. power to a home anywhere in the world) with no resistance and hence with no power wasted in transmission. Practical application of these materials has long been hampered by the infeasibility of the low temperatures needed to make these materials superconduct. Before 1986, materials were seen to be superconducting only at very low temperatures (typically less than 20K or –420 F) ; however in 1986 the discovery of a new class of superconductors with insulating, antiferromagnetic parent compounds led to the development of materials with much higher superconducting temperatures. After a wave of various discoveries, materials were found to superconduct at temperatures as high as ~140K or about –200 degrees Fahrenheit. Although this is still very cold, it is well above the temperature achieved by cooling through easily attainable and cost effective liquid nitrogen.

The physics of this new class of relatively high temperature superconducting materials (high-Tc materials) is still not understood. Specifically the role of magnetism within the superconducting mechanism itself is a subject of great controversy. By studying the interplay of magnetism and superconductivity within these materials, we can better understand the physics involved and potentially design materials with even higher superconducting temperatures. Our group studied the behavior of magnetism within $YBa_2Cu_3O_{6.6,}$, one of these high-Tc materials, through neutron scattering techniques. Anomalous behavior in the structure of the magnetic excitations we observed may provide greater insight towards the development of a theory explaining the fundamental mechanics of the superconducting mechanism itself (*Nature* **429**, 531 (2004)).

Universality in spin excitations of high-Tc supercondcutors

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Education:

Stephen Wilson, a new graduate just joined my group last year, worked on magnetic field effect on magnetic excitations in superconducting $YBa_2Cu_3O_{6+x}$. The posdtoc, Dr. Shiliang Li, is working to grow electron-doped high-Tc superconductors $Pr_{0.88}LaCe_{0.12}CuO_4$ to be used for similar experiments at ISIS, the world's most powerful spallation neutron source.

Societal Impact:

The discovery of similar magnetic excitations in different high-Tc superconductors will provide clues to why these materials are superconducting and different from other materials. Understanding high-Tc superconductivity will in turn allow us to design materials with even higher superconducting transition temperatures.